December 1998 Highlights of the Pulsed Power Inertial Confinement Fusion Program

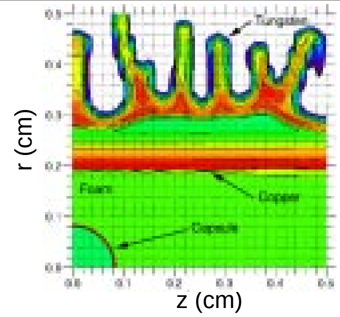

Fig. 1. Density contour plot from simulation of Z Shot 324 showing instability of imploding W sheath. Cu cylinder is 2-µm thick, 5-mm diameter, and 1-cm long; capsule is filled with D_2.

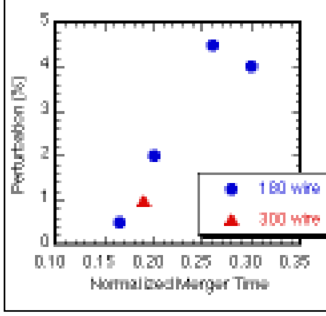

Fig. 2. Perturbation amplitude used in Mach2 simulation vs normalized merger time (merger time/implosion time) to match rise-times. Longer implosion times require lower perturbation levels.

There were 12 Z shots in December: 3 LLNL shots to measure gold opacity, 2 tungsten array shots to evaluate z-pinch energetics for code validation, a magnetic flux compression shot, 2 shots to prepare for equation of state experiments with D_2, and 4 z-pinch-driven hohlraum shots. Because of a budget shortfall, we are reducing the staff and contractors, delaying the first backlighter shot until December 2000, and reducing the total shooting days on Z in FY99 to 150-160 days.

We took the third in a series of proof-of-principle shots, in collaboration with French scientists, to evaluate plasma-armature magnetic flux compression as a means to compress the radiation pulse. An 8-cm-diameter, 6-cm-long tungsten array was used as the plasma armature. The array was imploded in ~100 ns by 3/4 of the Z drive current. The remaining current, together with an externally-applied 2 T axial field, provided the seed flux inside the array. The array imploded onto a conical central stalk, compressing the trapped field into the load region and causing a rapid increase in the current flowing in a 1.6-cm diameter, 1-cm-long short circuit load. VISAR probes and B-dots measured the magnitude of the compressed field. Preliminary VISAR data suggest the peak current in the short circuit load was ~19.5 MA. The rise time of the current pulse is ~40 ns. This technique has the promise of improved z-pinch radiation generation and a reduction in the pulsed power and power flow risk in future z-pinch drivers.

Recent improvements in the 2D radiation/magnetohydrodynamics (MHD) version of LASNEX have allowed us to develop the capability to perform fully-integrated dynamic hohlraum simulations. We are using this capability to model the capsule experiments that were fielded in October on Z. With good resolution, we can now model the capsule embedded in the foam-filled, copper dynamic hohlraum, including the Rayleigh-Taylor (R-T) unstable sheath dynamics of the imploding tungsten wire plasma (Fig. 1). After further refinements, we will begin fully-integrated 2D design work for near-term capsule experiments and investigate ICF dynamic hohlraum concepts for the follow-on machine to Z (ZX) and for high-yield.

The behavior of lower-velocity, long-implosion-time wire arrays has been modeled with the 2D MHD code MACH2 to prepare for long-pulse-mode Z experiments beginning in January. Long pulse experiments and modeling have already been studied on Saturn (May 1998 *Highlights*). These experiments showed that the long pulse mode can produce the same total x-ray power as the usual short pulse mode. Simulations, in conjunction with a heuristic model of wire array initiation (Imperial College), indicate that long current drive times result in more uniform initial conditions. This leads to a lower perturbation level computationally and correlates to the merger time of the wires. Verifying these results for the heavier arrays on the higher-current Z is important because of the reduced cost and power flow risk for future z-pinch machines. MACH2 simulations are in progress in preparation for the upcoming experiments on Z.

The three-member external team that reviewed the conceptual design for the Z/Beamlet backlighter issued its report. The team is comfortable about the design of the laser facility and the beam transport system. Recommendations were made to enhance the success of the backlighter for weapon physics applications as the project moves forward. These include attention to the effect that the shocks created on Z have on the final optics, addressing beam pointing after transport over the 36-m path length between the two buildings that house the laser and Z, further study to determine if area-source (as opposed to point-source) needs can be met at reduced power and how to field detectors close to the load, and analysis to quantify the risk in achieving the required spot size of 0.5 µm.

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